НАУЧНО-ТЕХНИЧЕСКИ СЪЮЗ ПО МИННО ДЕЛО, ГЕОЛОГИЯ И МЕТАЛУРГИЯ
SCIENTIFIC AND TECHNICAL UNION OF MINING, GEOLOGY AND METALLURGY
НАУЧНО-ТЕХНИЧЕСКИЙ СОЮЗ ПО ГОРНОМУ ДЕЛУ, ГЕОЛОГИИ И МЕТАЛЛУРГИИ

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B. Investigation of the stress condition and strain state of the rock mass.
C. Geomechanical provision of mining and civil engineering - models, methods and software.
D. Mine surveying geodetic and geophysical methods used in geomechanics.
E. Geodynamic impact on the rock mass.
F. Environment protection in mining and construction activities.

TOPIC A

Physical and mechanical properties of rocks and structural characteristics of the massif

Физико-механични свойства на скалите и структурни характеристики на масива

Физико-механические свойства пород и структурные характеристики массивов

PHYSICAL - MECHANICAL CHARACTERISTICS OF PRECAMBRIAN CARBONATE MASSIF ON SUVA MOUNTAIN, THE REPUBLIC OF NORTH MACEDONIA, AS CONSTRUCTION MATERIAL

Gorgi Dimov[1], Blagica Doneva[1]
[1]University of Goce Delcev, Faculty of natural and technical sciences, Stip, gorgi.dimov@ugd.edu.mk

ABSTRACT
The paper represents the physical and mechanical characteristics of marbleized limestones from the Precambrian carbonate massif on Suva Mountain, the Republic of North Macedonia. Investigated terrain is locality called Jarova Glava. It is situated southwest of Skopje and occupy an area of about 0.5 km².
From macroscopic analyses can be concluded that the area is composed mainly of medium granular marbleised limestone with light grey colour and massive structure.
The physical – mechanical characteristics of the material (high pressure strength, high wear resistance, frost resistance etc.), their chemical composition and mineralogical – petrographic characteristics showed that his material can be used in civil engineering for concretes with high strength features.
***Keywords**: marbleized limestones, physical – mechanical characteristics, chemical composition, Suva mountain.*

Introduction

Investigation Area "Jarova Glava" is located southwest of Skopje, as an integral part of the mountain massif consisting of the Vodno and Suva Mountains that build the northern part of the Vardar Zone. Most of the terrain has a flat mountain and high mountain character with the exception of the Markova River valley (Fig. 1).

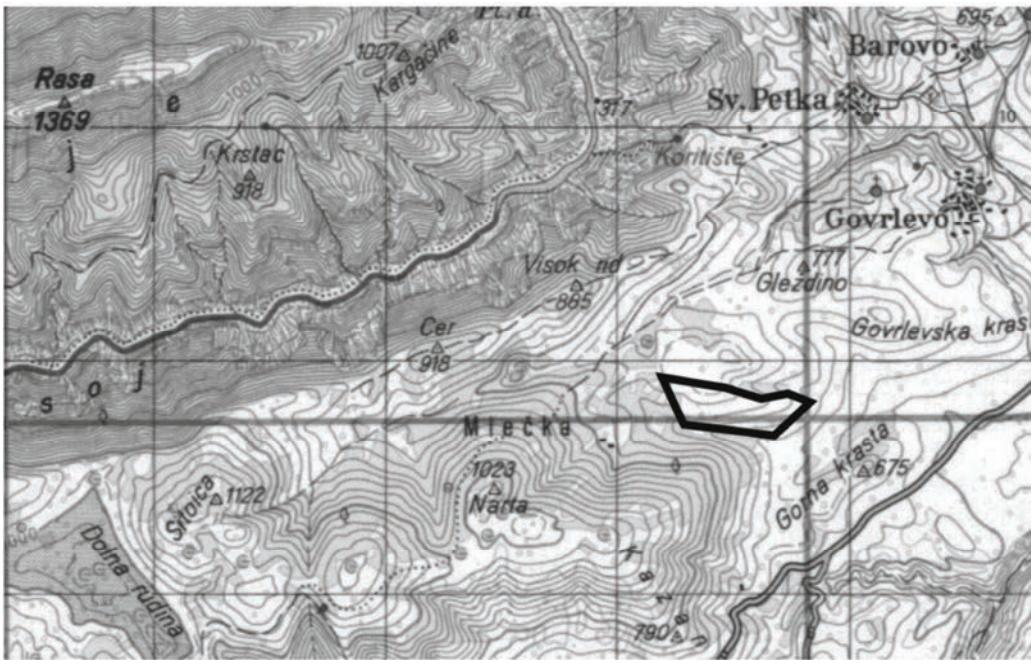

Fig. 1: Geographical position of the investigated area

The southern slopes of Vodno are quite eroded and covered with bushes and degraded forest. The hydrographic network is represented by several small streams of temporary character that dry out in the summer months. These watercourses flow into the Markova River, which is the main drainage artery of the whole area.

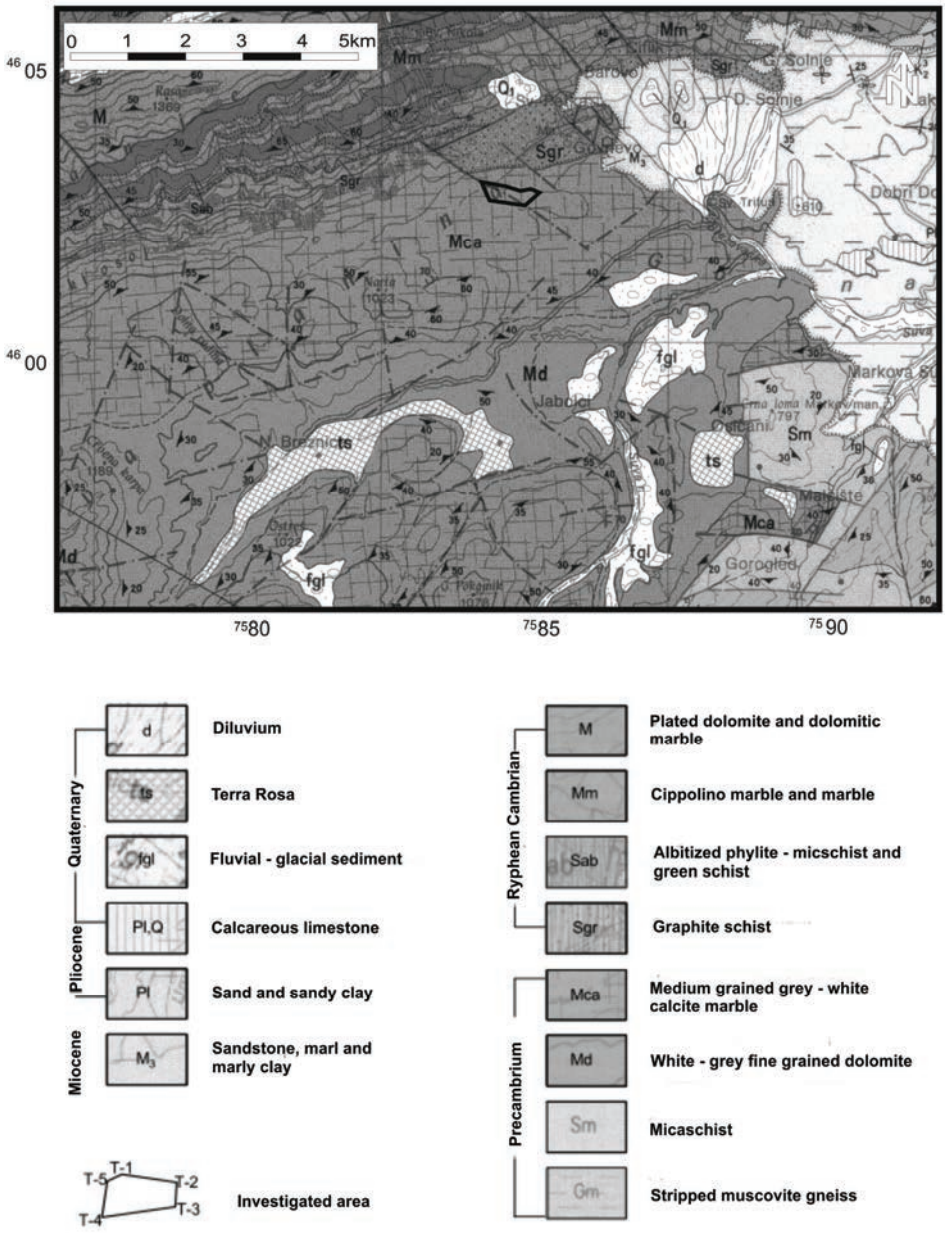

Fig. 2: Geological map of the vicinity of the investigated area [1]

In the wider vicinity of the research area there are numerous of different lithological composers that were formed during different periods of the earth's crust development. Precambrian is represented by stripped muscovite gneisses (Gm), micashists (Sm), white - grey fine grained dolomites (Md), Mid-grained gray - white calcite marbles (Mca), Ryphean - Cambrian is present with graphitic schists (Sgr), Albitized phylite micaschists and green schists (Sab), Cippolino marbles and Marbles (Mm), Plated Dolomites and Dolomite Marbles (M), Miocene is represented by sandstones, marls and marly clays, Pliocene (Pl) - sands and sandy clays (Pl), calcarous limestone (PlQ), and Quarternary is present with glacial - fluvial sediments (fgl), terra rossa (ts) and deluvium (d) (fig. 2).

The rocks present in the investigated field, in terms of their hydrogeological function can be classified as follows:

- hydrogeological collectors with fissure - karst type of porosity, where are classified calcite marbles and

dolomites.

- gravels and sands of quaternary age are designated as hydrogeological collectors with granular type of porosity.

- as a hydrogeological complex is separated the whole Miocene, where are classified clays and marls as relative hydrogeological insulators and sandstones are typical hydrogeological collectors with fissure type of porosity.

- Relative hydrogeological insulators where are classified micaschists and schists.

- Glacial - fluvial sediments, terra rossa and deluvium are separated as hydrogeological insulators due to the presence of a clay component that, the most often, is cement mass. [3]

In terms of structural and geological features, the investigated terrain is characterized by a very simple structure. When it comes to crack systems, the most dominant is the foliation marking system (which is not strongly expressed and extends northeast - southwest with an incline angle of about 60 degrees), and a single fissure system almost normal to the first one and with subvertical incline angles. For these reasons, the entire massif Jarova Glava is strongly cracked and most often the blocks are decimeter and very rarely metric in size.

Fig. 3: Part of the investigated area Jarova Glava

Geological features of the marbleized limestone

Macroscopically, the rock has a light gray color, mainly with lighter parts, which are in places as lens shaped larger forms with thicknesses up to several cm in size. Has a solid, massive structure with medium grained composition. With cold diluted HCl, it reacts, indicating mainly calcite composition (Fig. 3). [2]

Microscopically, it is seen that it is monomineral calcium carbonate rock, mainly composed of calcite and, as secondary is present dolomite. The rock has an unclear heterogranoblastic structure. This structure is conditioned by the appearance of finer calcite - dolomite crystals, which are poikilitic incorporated into larger calcite forms. The size of the microcrystals is 30 - 100 microns, while the larger shapes are up to 2 - 3 mm. The same larger shapes are not quite clear. Part of the microcrystals have a hydidomorphic form, which may be dolomite crystals. Most have an allotriomorphic structure, indicating that dolomite is not very abundant.

There is a certain orientated texture, so the larger calcite shapes are quite elongated in one direction. In rare crystal forms can be noticed cleavage as parallel polysynthetic lamellae.

Rare cavities occur, up to 1-1.5 mm in length, and, also, there are smaller, but are rare. Overall, porosity is poorly represented.

As secondary minerals appear rare quartz grains, and quite rare muscovite leaf, which are traces in marble.

Physical - mechanical parameters of marbleized limestone

The examinations for compressive strength of the marbleized limestone were performed on dry and water-saturated cubes with size 5 × 5 × 5 cm, and the abrasion resistance test was performed on cubes with size 7 × 7 × 7 cm in dry condition.

The obtained results of the laboratory examinations of the physical-mechanical characteristics of the marbleized limestone from the locality "Jarova Glava" expressed as mean arithmetic value are presented in Table 1.

The following characteristics were examined: [5]

1. Compressive strength in dry state
2. Compressive strength in a water saturated state
3. Water absorption
4. Abrasion resistance - (Bohme)
5. Volume mass with pores and cavities
6. Volume mass without pores and cavities
7. Coefficient of volume mass
8. Porosity
9. Persistence of effect of ice

Table 1. Physical - mechanical characteristics of marbleized limestone

No.	Test	Standard	Unit	Mark	Results	Quality criterion BET/MKS B.B2.009 BNS/MKS U.E9.021/028 AB/MKS U.E9.028
1	Compressive strength in dry state	B.B8.012	MPa	σ_p ***min***	*90,80*	BET/min (80; 160) BNS/min (100) AB/min (120, 140; 160) Tampon/min (100; 120)
				σ_p ***max***	*108,30*	
				σ_p ***avg***	***102,20***	
2	Compressive strength in a water saturated state	B.B8.012	MPa	σ_p ***min***	*84,47*	BET /min (64; 128)
				σ_p ***max***	*96,11*	
				σ_p ***avg***	***91,54***	
3	Compressive strength after 25 cycles of freezing and defrosting	B.B 8.012	MPa	σ_p ***min***	*78,25*	25% lower compressive strength than standard
				σ_p ***max***	*89,40*	
				σ_p ***avg***	***84,33***	
4	Water absorption	B.B 8.010	% /m/m/	***U***	***0,1***	BET/max (1.0) AB/max (0.75; 1.0) Tampon /max (1,0)
5	Abrasion resistance	B.B 8.015	$cm^3/50\ cm^2$	***Ab***	***25,79***	BET/max (35.0) AB/max.(12.0, 18.0; 35.0)
6	Volume mass with pores and cavities	B.B 8.032	kg/m^3	γ_r	***2690***	(2000 - 3000) kg/m^3
7	Volume mass without pores and cavities	B.B 8.032	kg/m^3	γ_z	***2730***	(2000 - 3000) kg/m^3
8	Degree of density	B.B 8.032	% /m/m/	***G***	***98,5***	/
9	Porosity	B.B 8.032	% /m/m/	***P***	***1,5***	/
10	Persistence of effect of ice	B.B 8.001	Damages and lost /%/	***M***	*No major damage; Mass loss below 1%*	BET/max (5.0) AB/max (5.0) Tampon/ max (10.0;12.0)

Chemical analysis

The average composition of the studied samples has been listed in table 2. The results revealed that CaO is the main oxide in all studied samples.

Table 2. Average chemical composition of the marbleized limestone

SiO_2	0.40 %
Al_2O_3	0.1 %
Fe_2O_3	0.04 %
CaO	54.45 %
MgO	3.1 %
Na_2O	0.06 %
K_2O	0.03 %
P_2O_5	0.02 %
SO_2	0 %
Moisture, H_2O	0.09%
LOI	40.4 %

Based on the analysis, the rock the rock contains no sulphates, sulphides, total sulfur and chlorides.

According to determined physical - mechanical characteristics, chemical composition and mineralogical - petrographic analysis, the examined rock from the locality “Jarova Glava” is a favorable and can be applied in various commercial branches, and can be applied in civil engineering for aggregate for making concrete mixtures as well as for tampon material. [4]

Conclusion

The investigation area "Jarova Glava" is located southwest of Skopje, as an integral part of the mountain range consisting of the Vodno and Suva Mountains. In the wider environment of the research area, there are number of different lithological composers that occurred at different periods of the earth's crust development. The most valuable for this investigation are Precambrian marbleized limestones.

Based on the conducted chemical analyses, marbleized limestone contains: SiO_2 - 0.40 %, Al_2O_3 - 0.1 %, Fe_2O_3 - 0.04 %, CaO - 52.97 %, MgO - 3.1 %, Na_2O, K_2O and P_2O_5 are present less than 1 %.

According physical - mechanical examinations of compressive strength in dry and water saturated state, water absorption, abrasion resistance - (Bohme), volume mass with and without pores and cavities, coefficient of volume mass, porosity and persistence of effect of ice, marbleized limestone has favorable properties and can be successfully used as tampon in transport infrastructure and as raw material for aggregate for making concrete mixtures.

From the conducted geological investigation on the mentioned locality, can be concluded that this raw material is present in sufficient quantity for exploitation.

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